Airborne Snow Observatory

Knowing the mountain snowpack for water resources and snow science

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Western Water Assessment

McGurk Hydrologic

NSIDC
National Snow and Ice Data Center

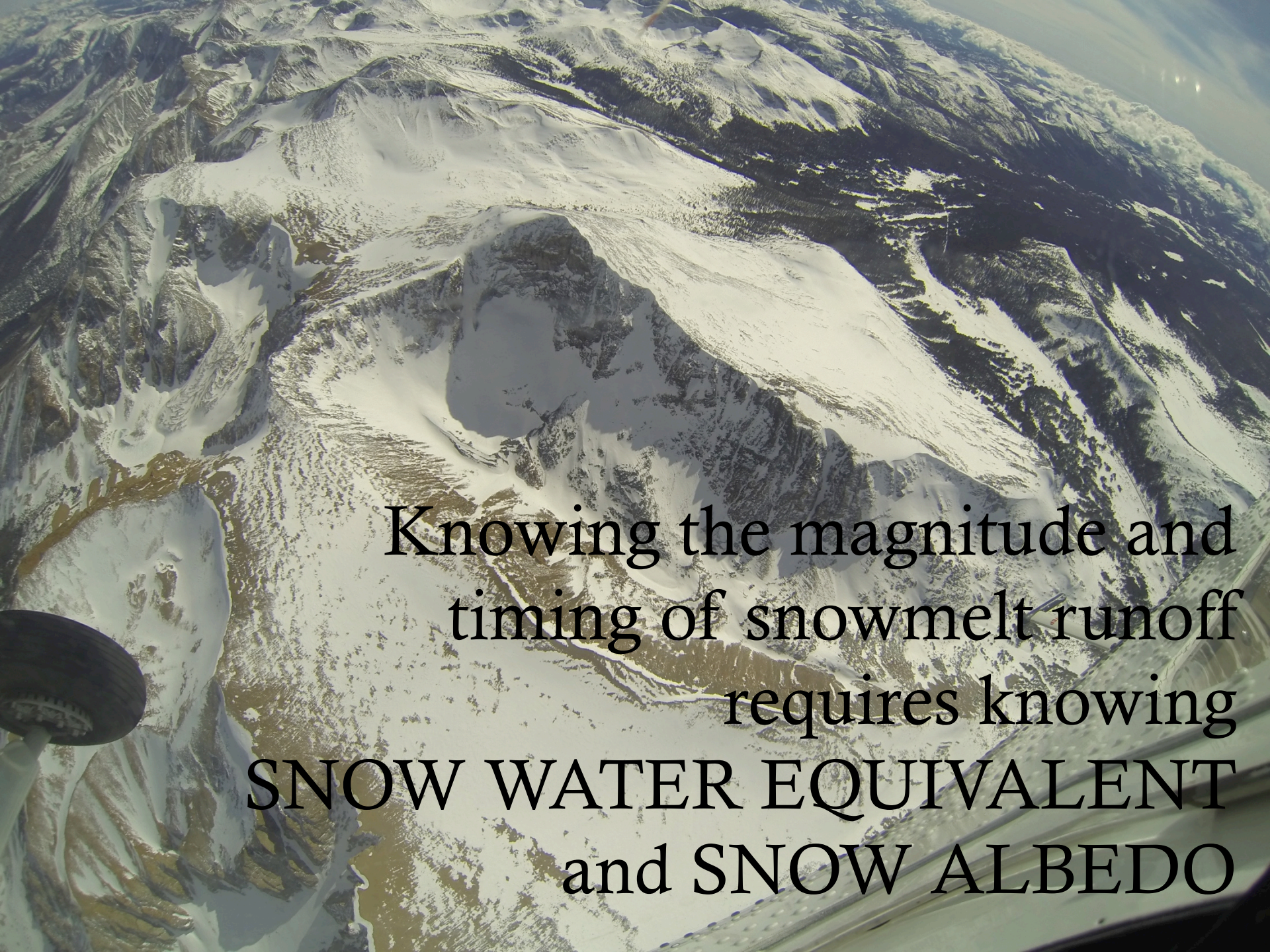
Water from Snow

About 75% of the Western US freshwater supply comes from snowmelt.

Reservoirs in California hold about a year and a half of annual runoff, making for strong sensitivity to interannual variability in snowfall

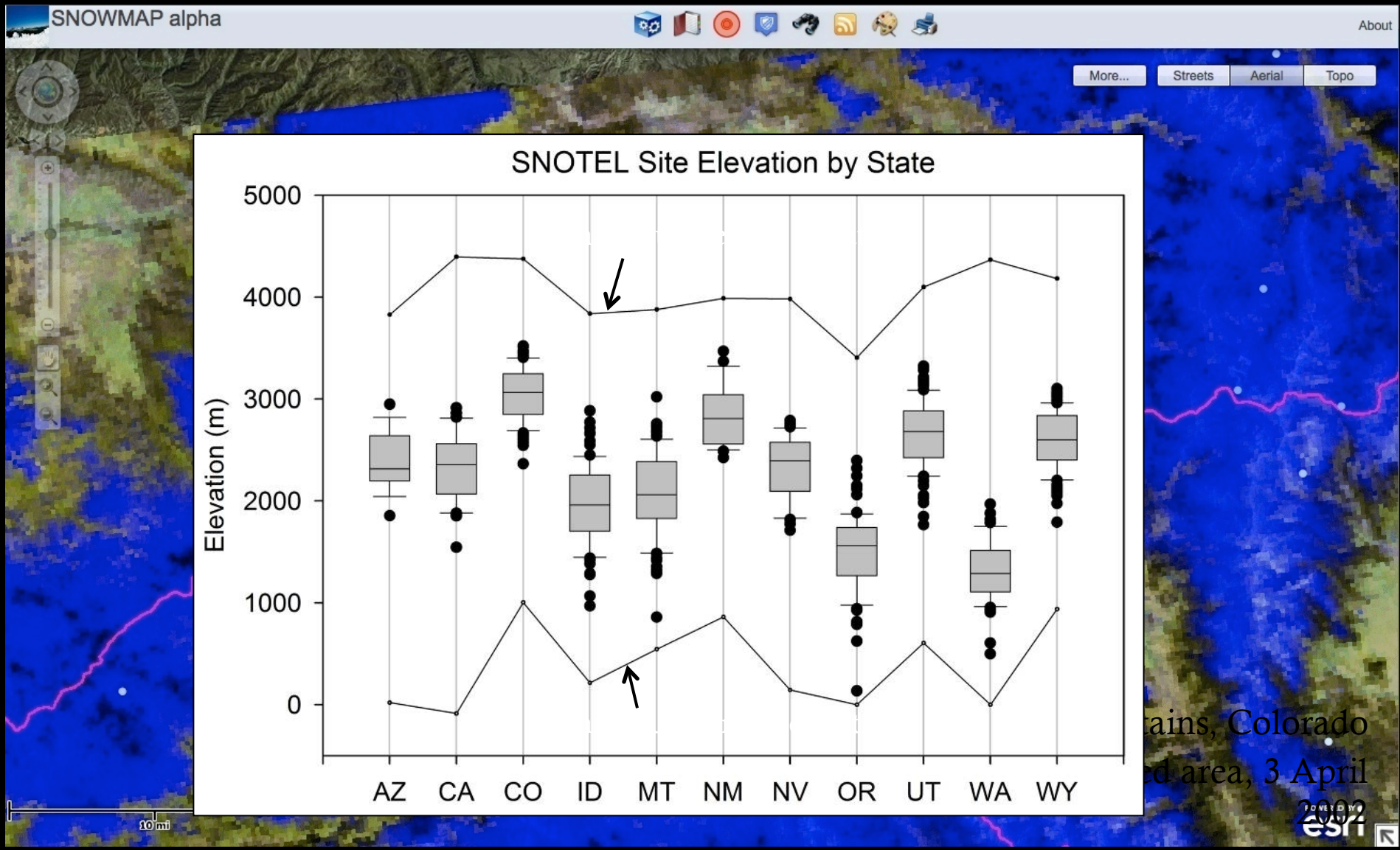
The definition of optimization of reservoir storage, hydroelectric generation, achievement of environmental metrics depends on the timing and magnitude of runoff and varies from basin to basin

Snowmelt modeling and forecasting is migrating to physically based models, ultimately demanding markedly better snow information


Knowing the magnitude and
timing of snowmelt runoff
requires knowing
SNOW WATER EQUIVALENT
and SNOW ALBEDO

This is how we have known SNOW WATER EQUIVALENT

Operational snow monitoring




The way we
want to see it

Imaging Spectrometer
0.35-1.05 μ m
2 m spatial resolution from 4000 AGL

Albedo

3D Scanning LiDAR
1064 nm
1 m spatial resolution

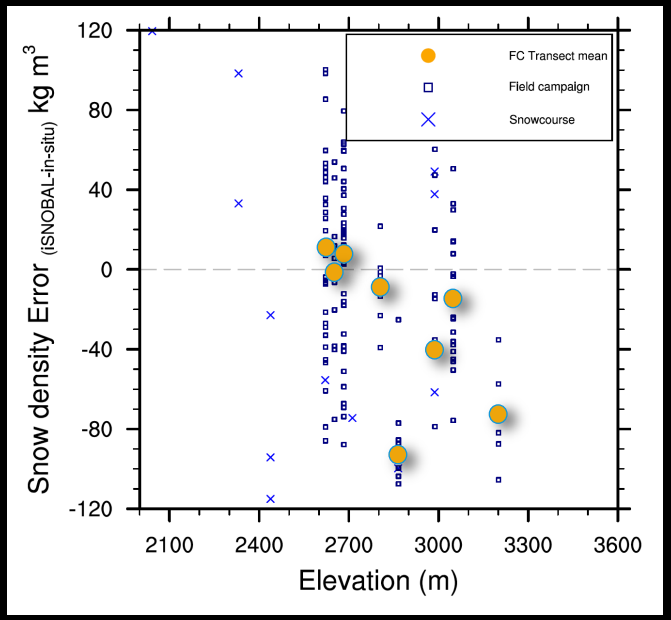
Snow Water Equivalent

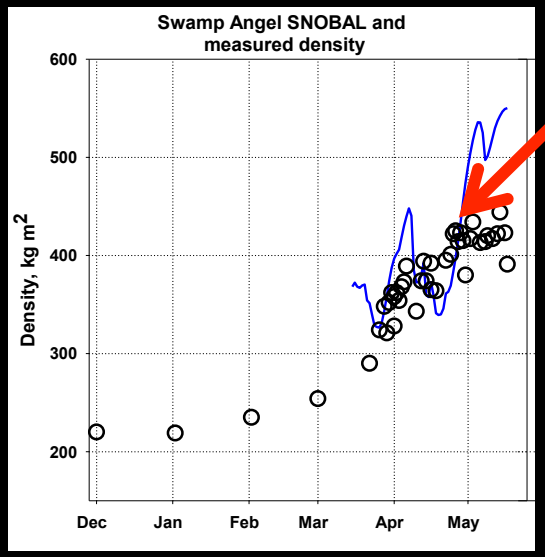
Snow Density Modeling

Mean error
-26 kg/m^3

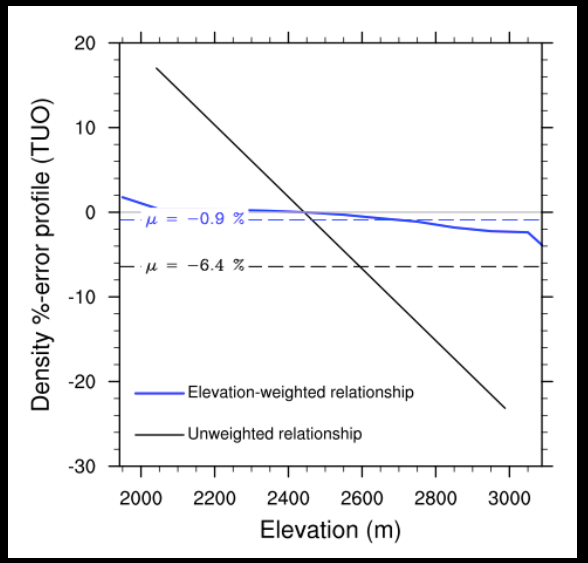
MAE
31 kg/m^3

Elevation bias



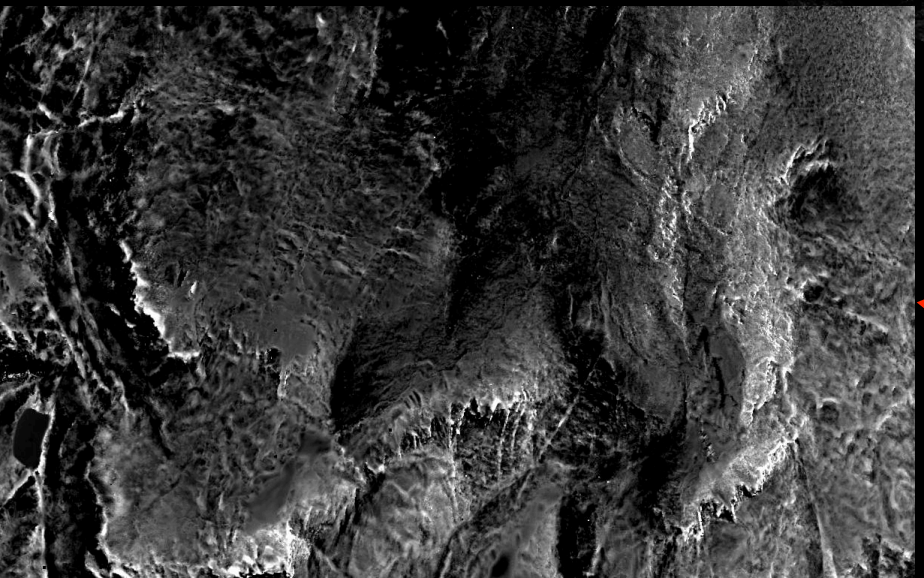


SWE very low is when densities fall apart -



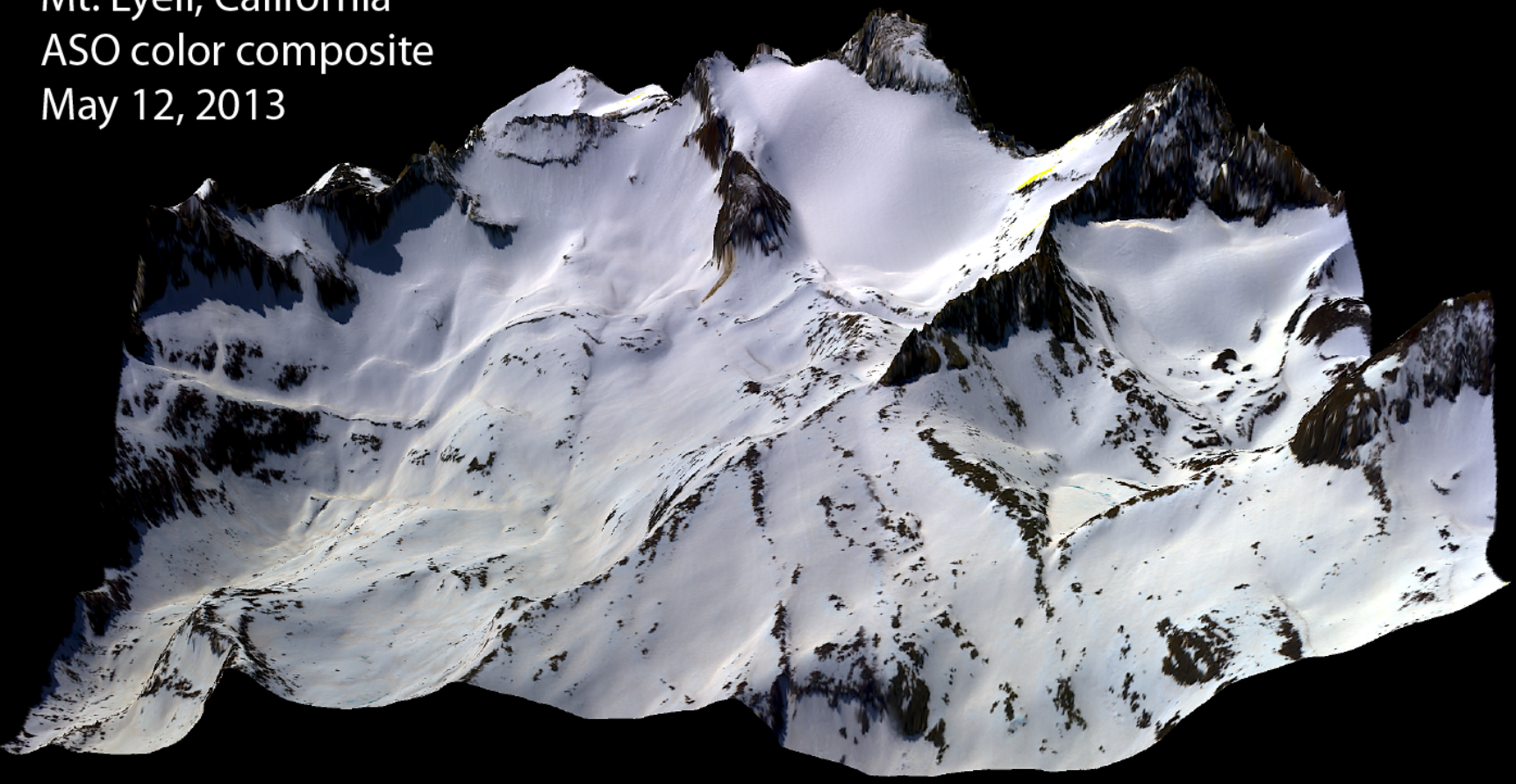
Unprecedented snow depth and snow water equivalent detail at full basin scale.

ASO Snow Depth
Tuolumne River Basin
April 2, 2013

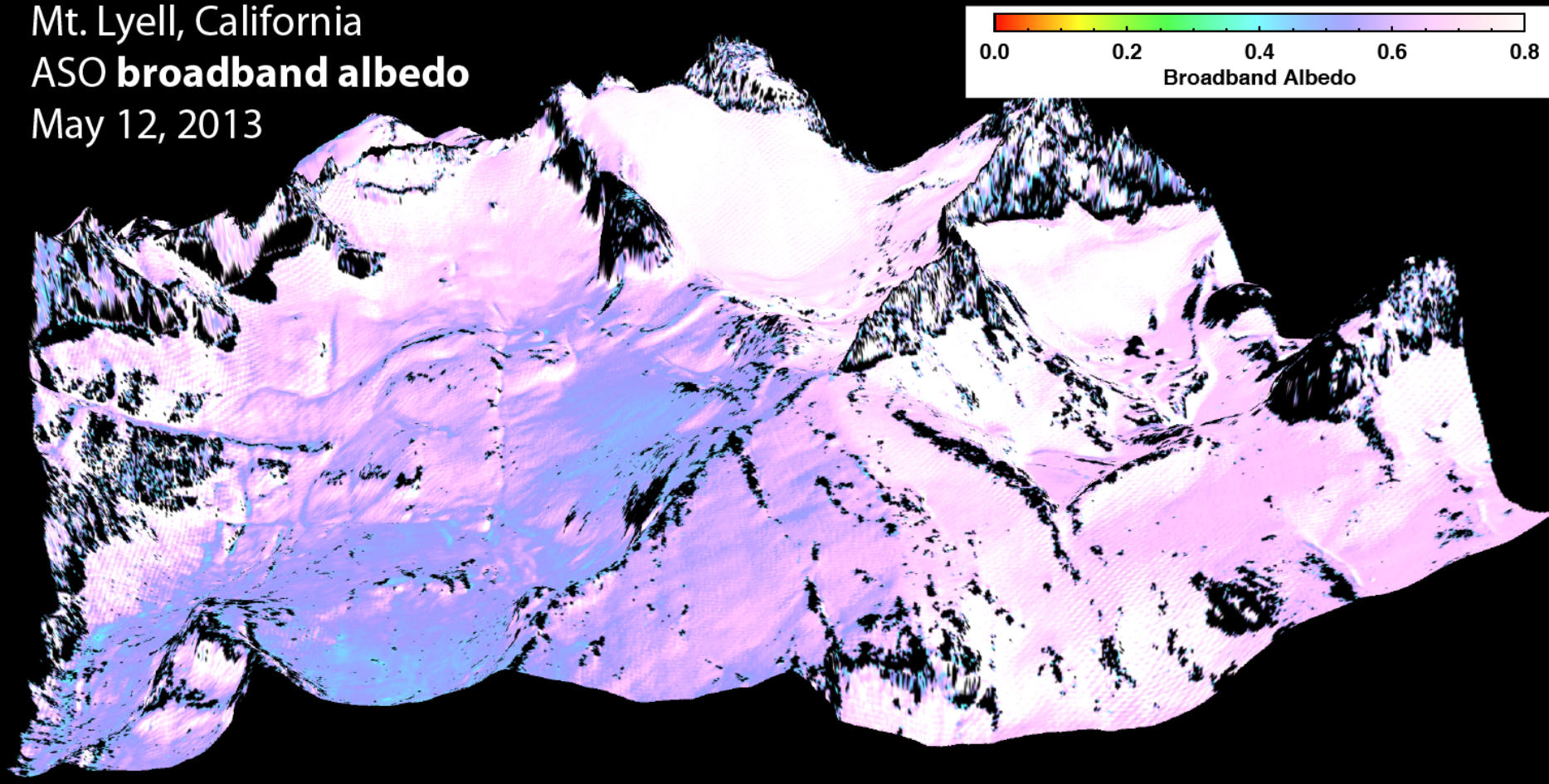


ASO-DM1 Results

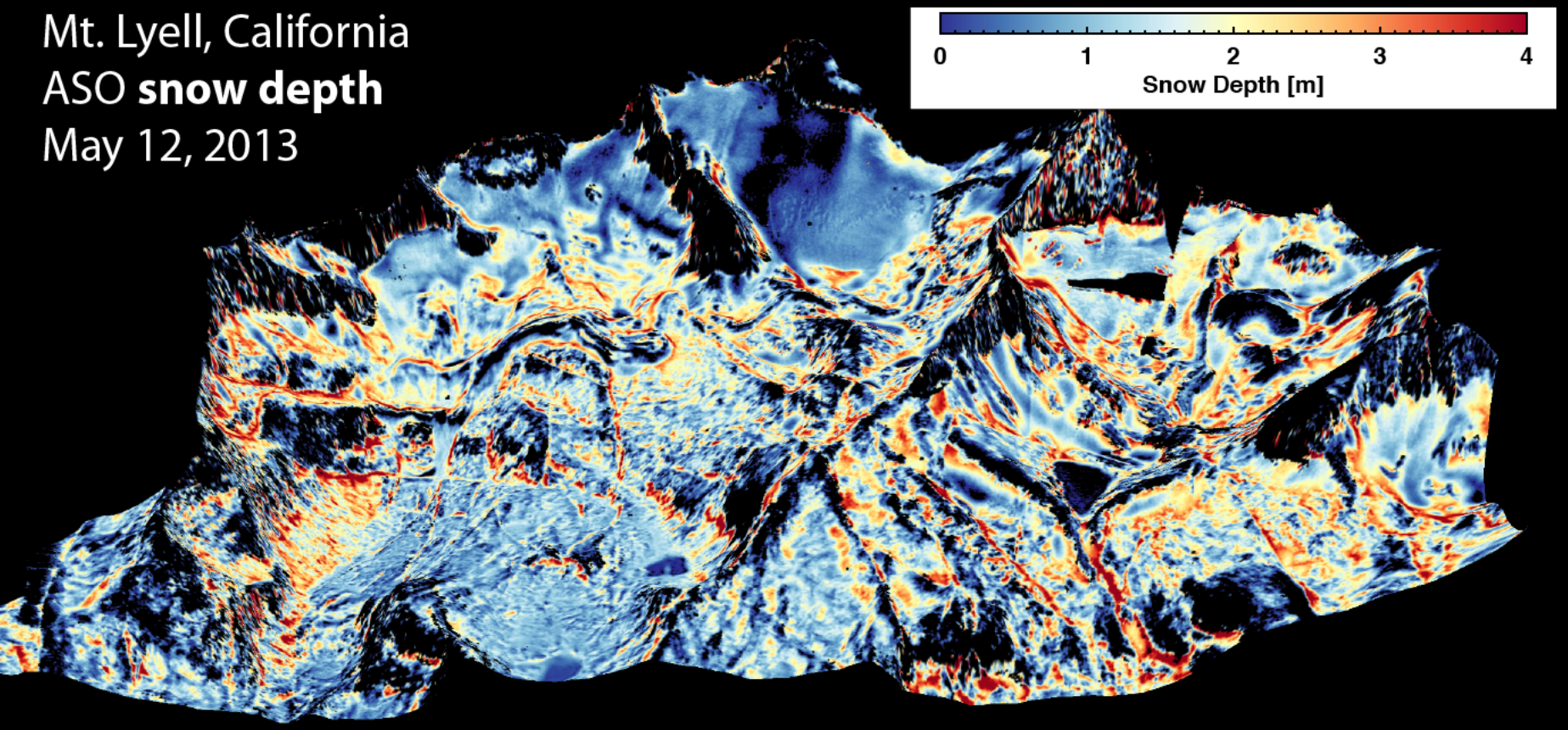
Mt. Lyell, California
ASO color composite
May 12, 2013

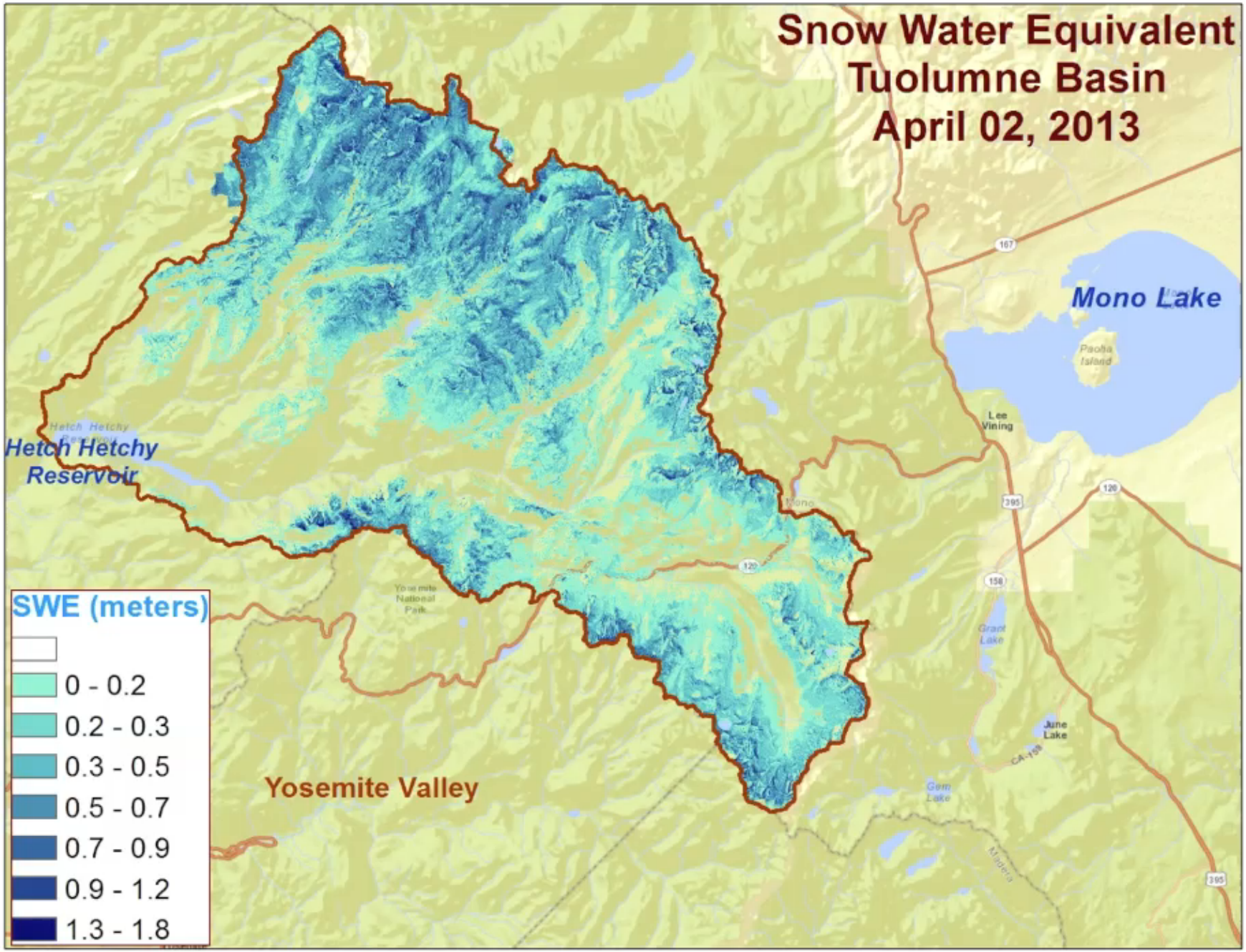


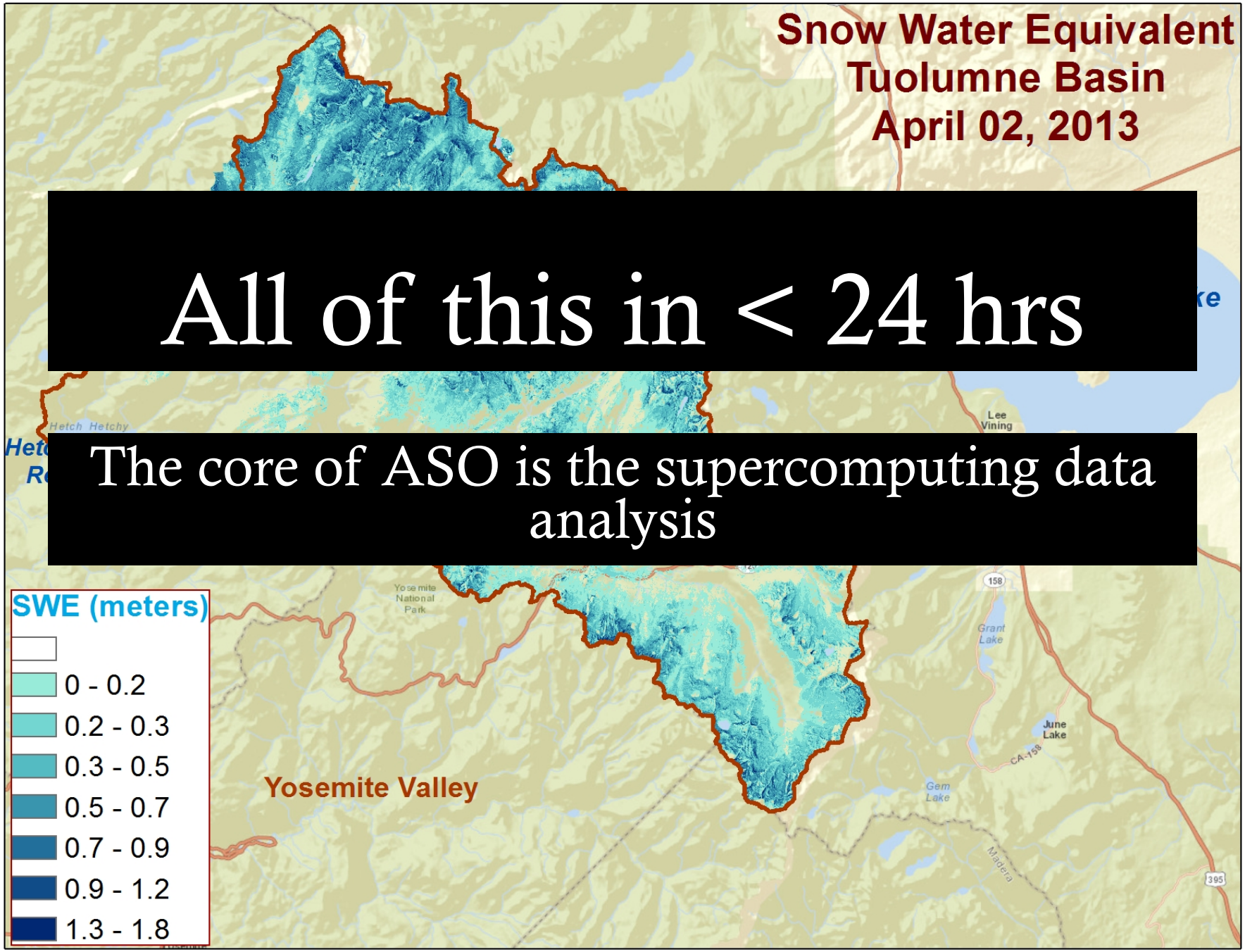
ASO-DM1 Results



ASO-DM1 Results

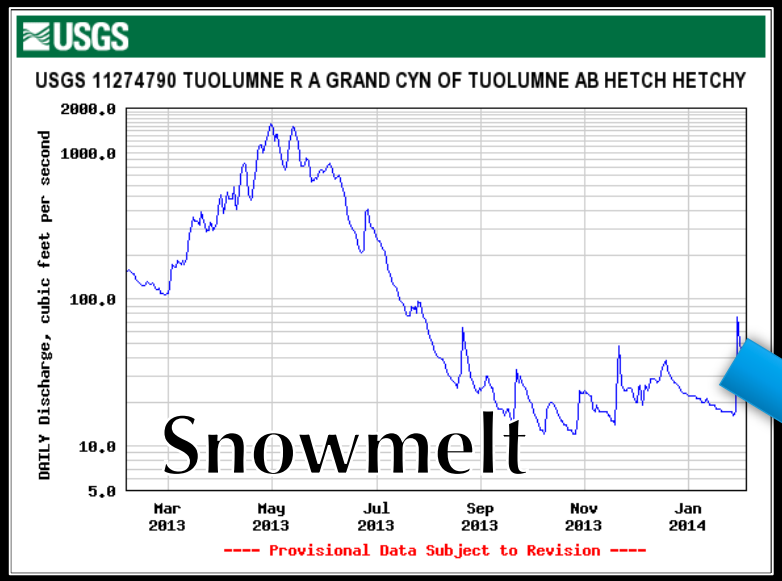


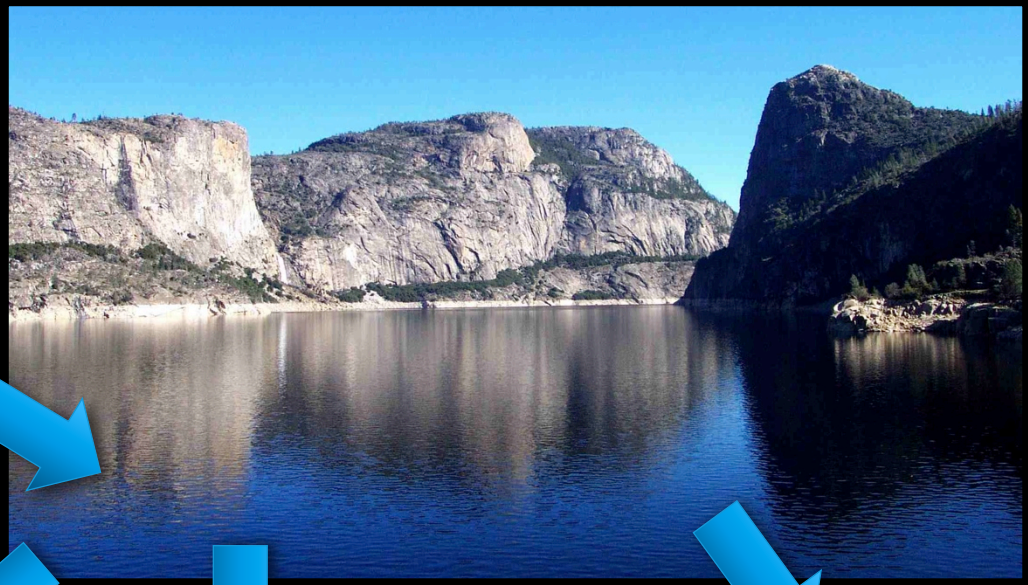

Snow Water Equivalent
Tuolumne Basin
April 02, 2013
Mono Lake
Hetch Hetchy Reservoir
Yosemite Valley
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8

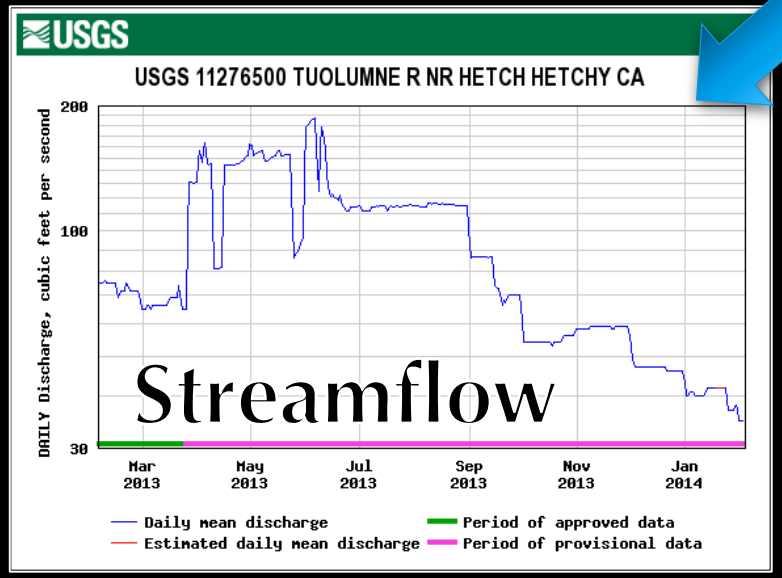

Snow Water Equivalent
Tuolumne Basin
April 02, 2013
All of this in < 24 hrs
The core of ASO is the supercomputing data analysis
SWE (meters)
0 - 0.2
0.2 - 0.3
0.3 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1.2
1.3 - 1.8
Yosemite Valley
Hetch Hetchy
Lee Vining
Yosemite National Park
Grant Lake
June Lake
Gem Lake
Madera
158
395
CA-158

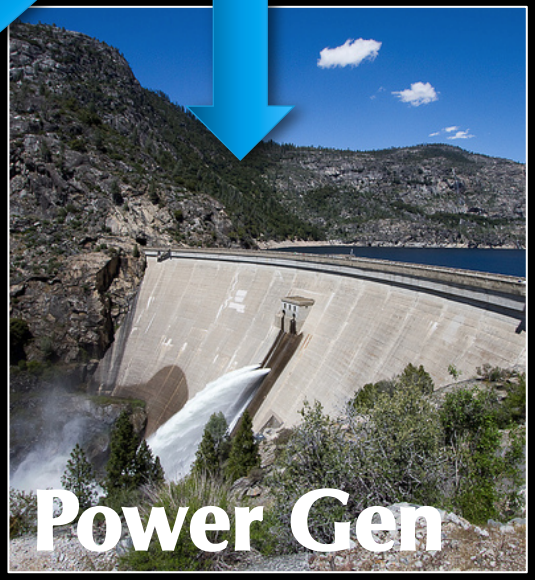
Hetch Hetchy Operations

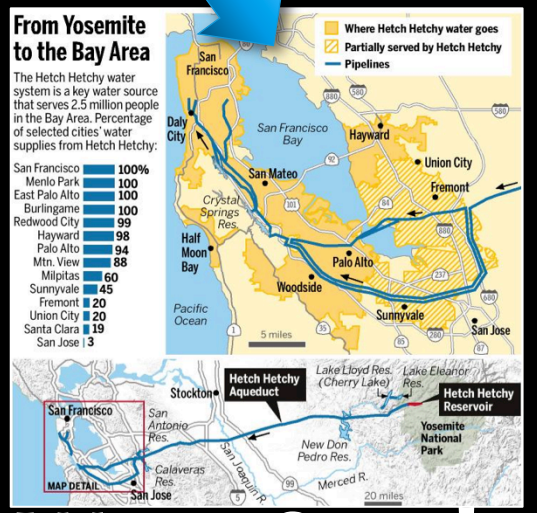
balancing streamflow, water supply, & hydropower needs





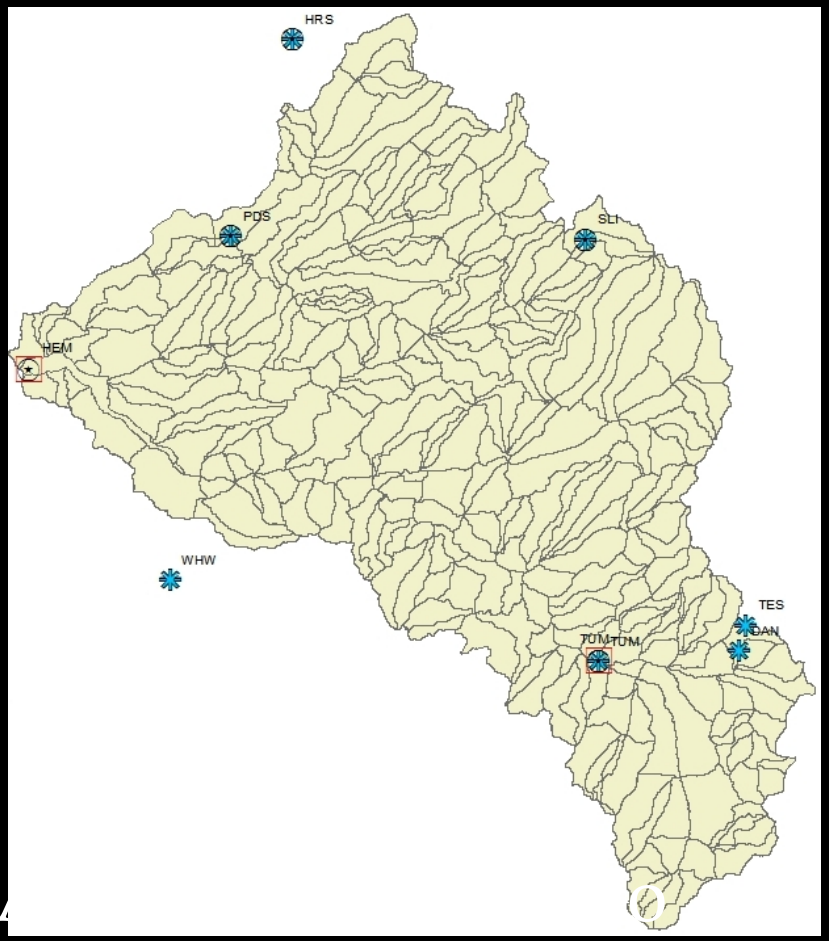




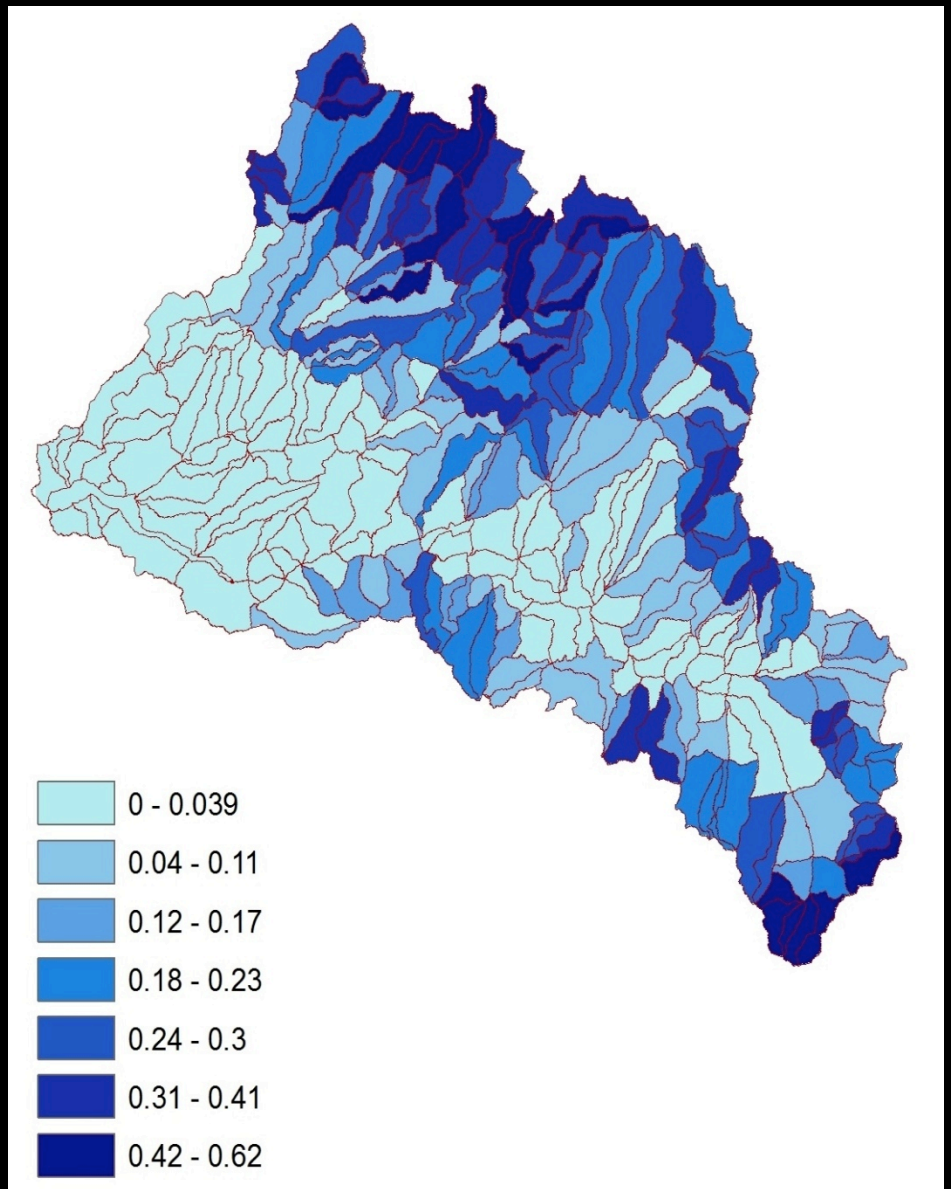


Tuolumne Basin above Hetch Hetchy Res.

SWE/Met Stations & PRMS Model Units

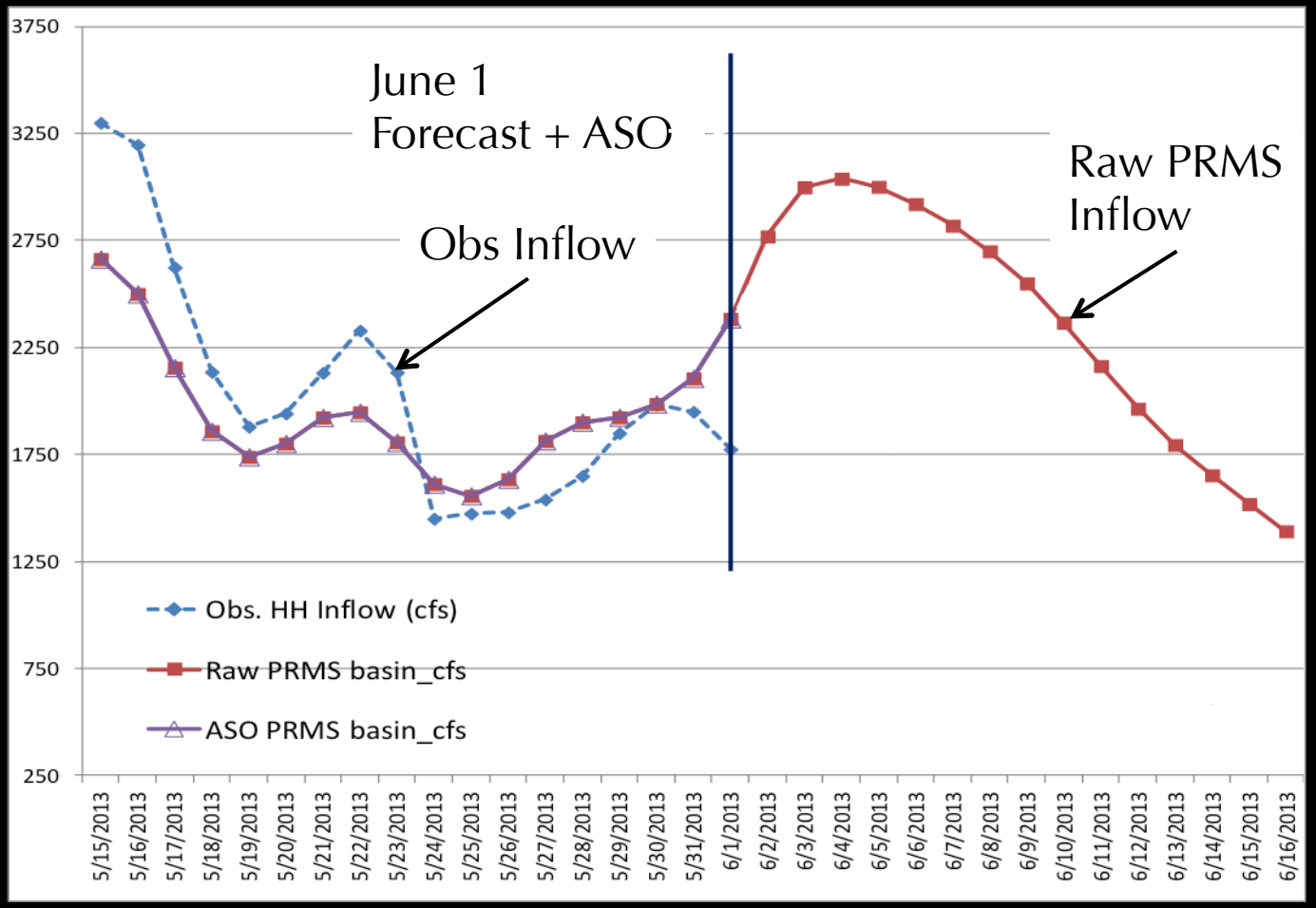


aggregated to PRMS model units



Hydro modeling results

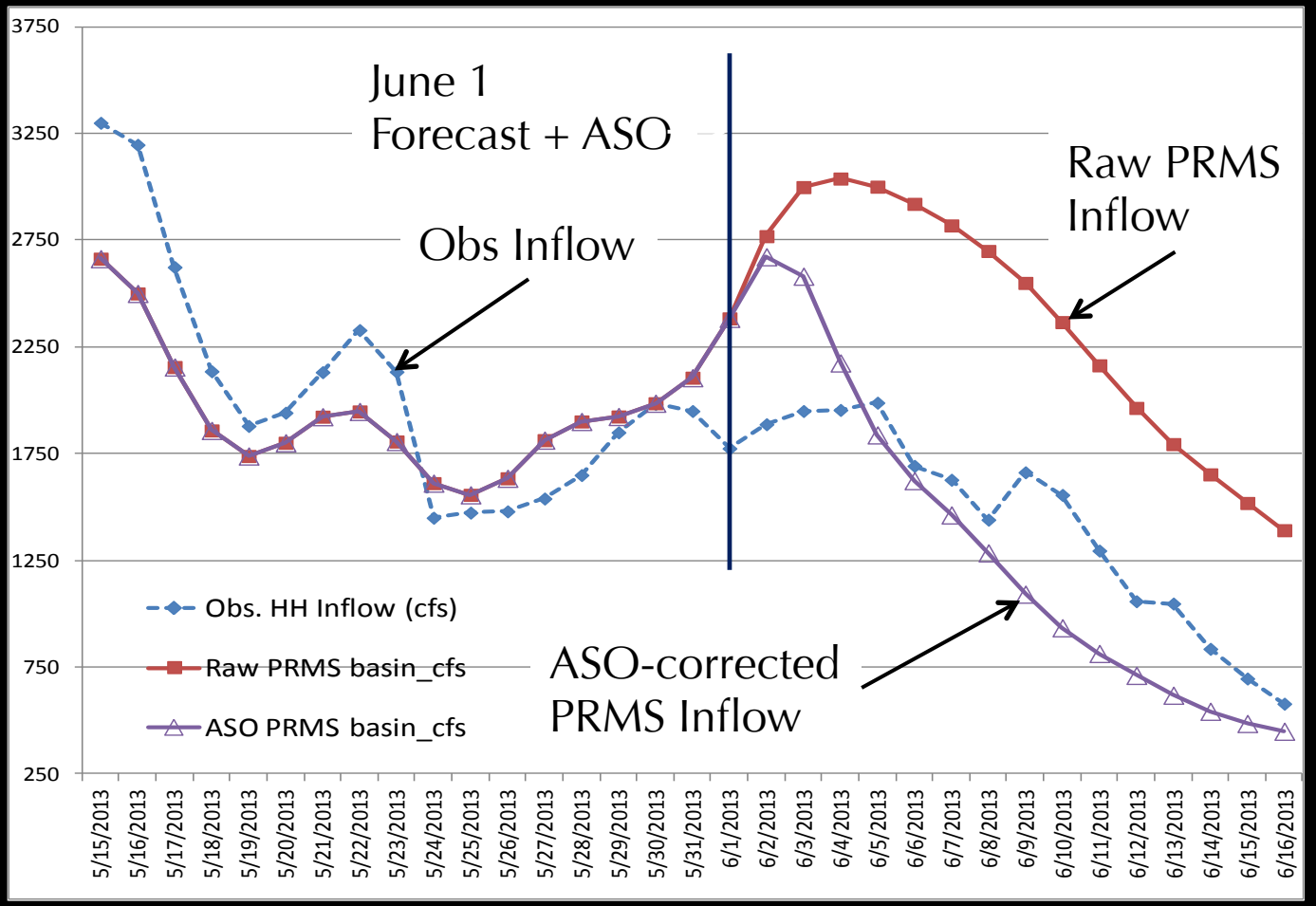
Hetch Hetchy Reservoir Tuolumne River, CA



- Precipitation and temperature were forecasted from 6/1
- Simulated and observed inflow are similar from 5/15 through 6/1, the forecast date
- Modeled SWE (red) corrected by ASO SWE (blue)

Hydro modeling results

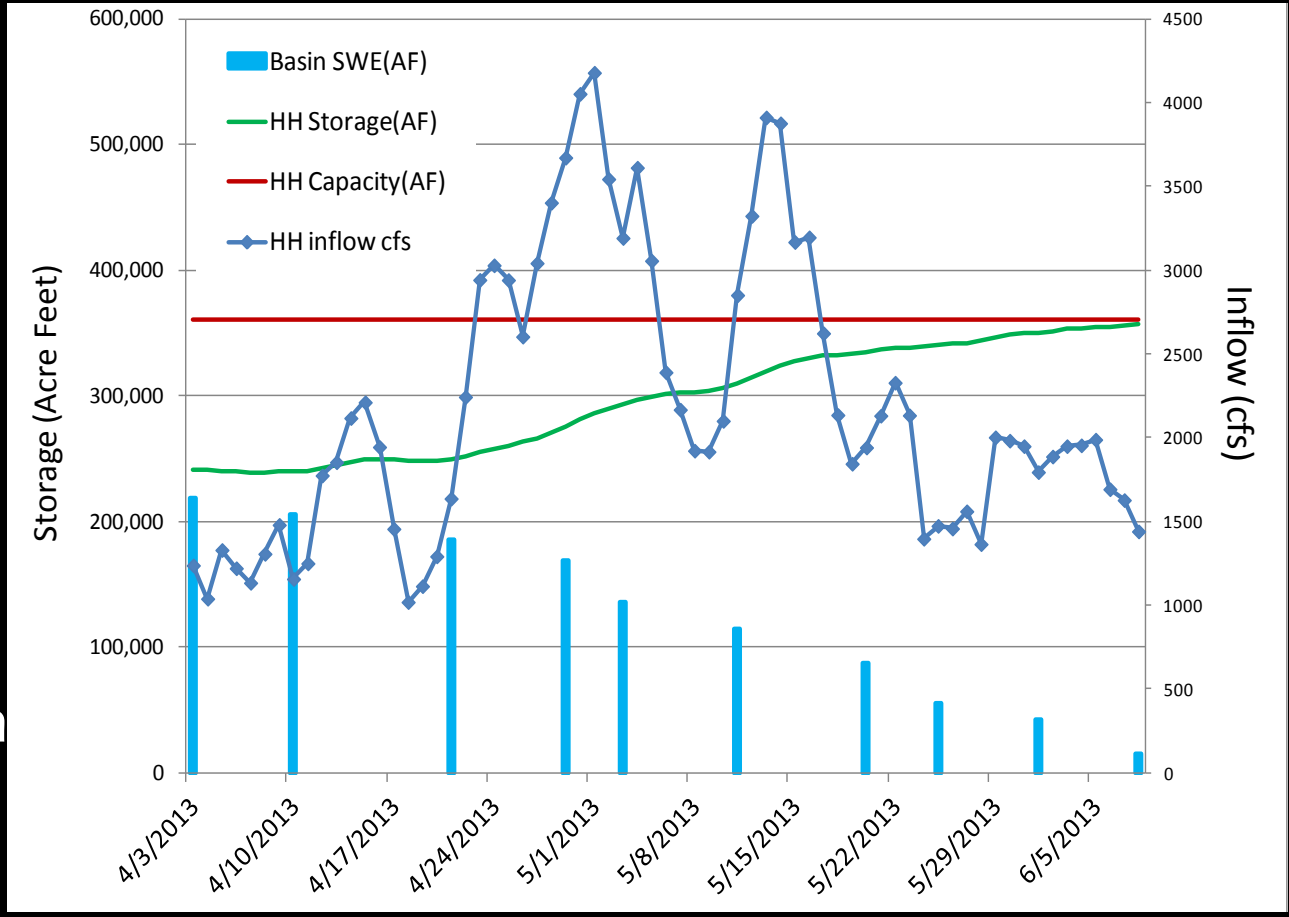
Hetch Hetchy Reservoir Tuolumne River, CA



- Observed inflow 28 TAF less than initial prediction
- ASO-corrected forecast closer to observed
- Reservoir operations adjusted (draft reduced) after ASO forecast
  - HH reached top of gates, was full
  - no water lost to spill

SWE/Runoff comparison

- Total Snow Water declined from 218 to 15 TAF in 65 days
- Reservoir storage reached capacity as last snow melted
- Melt rates peaked on May 1 based on solar input and snow extent, and then declined as snow extent decreased



ASO in 2014+

- We begin flying the Tuolumne on ~23 March
- Quantification of Tuolumne SWE should be available 24 March, weather permitting
- This spring is likely to be endmember snow season
- Rim Fire of 2013 in and near Yosemite is a science target for California, ecosystem scientists, and hydrologists. Our flights are key to understanding hydrologic response
- Implementation of new density modeling and physical constraints on density modeling
- Scaling to entire Sierra Nevada in coming years.